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A R G O N N E   N A T I O N A L   L A B O R A T O R Y

IDAHO DIVISION

REPORT OF EBR-II OPERATIONS

July 1, 1967 through September 30, 1967

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IDAHO FALLS, IDAHO

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M. Novick, Division Director

Contributors

B. C. Cerutti	K. J. Moriarty
D. W. Cissel	R. Neidner
R. O. Haroldsen	W. H. Olson
H. Hurst	T. R. Spalding
F. S. Kirn	W. R. Wallin
J. D. Leman	G. K. Whitham

Report Coordinated By

W. R. Wallin

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TABLE OF CONTENTS

TABLE OF CONTENTS (continued)

TABLE OF CONTENTS (continued)

TABLE OF CONTENTS (continued)

LIST OF TABLES

LIST OF TABLES (continued)

LIST OF FIGURES

LIST OF FIGURES (continued)

LIST OF FIGURES (continued)

LIST OF FIGURES (continued)

I. Operations

A. Summary

Run 25 was completed this quarter, and Run 26 was started. Power operation during the quarter included 735 MWd in Run 25 and 87 MWd in the first part of Run 26, called Run 26A, which was conducted between September 27 and 29.

At the beginning of the quarter, Run 25 continued with the reactor operating at 30 MWt and 10 MWe. Experimental subassembly X011 had previously been identified as one source of fission gas, and experimental subassemblies XG05 and XA08 had been re-installed in the core for 150 MWd of operation at a maximum reactor power of 30 MWt to determine if they released fission gas. Following this irradiation period, during which only normal fission-gas background readings were observed, the reactor was shut down to await approval of full-power operation. In the meantime, a small steam leak was repaired in the high-pressure flash tank to prevent limiting operation of the blowdown system. Reactor operation was started again on July 5, and the power was raised incrementally to 45 MWt while watching for a further fission-gas release. Routine power operation continued until July 20 without any abnormal fission-gas activity.

During the period of July 6 through 10, three special tests were performed. Heat rejection capabilities of the main turbine condenser system were measured. This was followed by a test to measure the reactor building heatup rate, which involved closing the main exhaust isolation valve from the reactor building for an extended period. This allowed the hot shield and thimble cooling exhaust air to recirculate in the reactor building until an equilibrium temperature was established. Equilibrium was established in about 24 hours without the exceeding of any maximum building temperature limits for power operation. A leak-rate test of the reactor building supply and exhaust valves was successfully completed immediately after the reactor building heatup rate test.

On July 20, the reactor was shut down, and experimental subassemblies X023 and X024 (containing special gamma-heat-measuring test capsules prepared by Oak Ridge National Laboratory) were installed in grid positions 2B1 and 7D4, respectively.

Measurements taken during the ensuing reactor startup for continuation of Run 25 revealed that the reactivity decrement was lower than previously measured, and the slope of the differential power coefficient was less than previously measured in the 15 - 25 MW power range. A program was immediately begun to obtain more precise power-coefficient measurements and to attempt to explain the change. Further power-coefficient measurements were made up to 20 MWt, and rod-drop experiments were performed, which verified that the prompt reactivity feedback characteristics of the reactor were still within safe operating limits. The following day these same measurements were performed again as the reactor

A. Summary (continued)

power was raised to 30 MWt. Irradiation of the experimental subassemblies X023 and X024 was completed at 30 MWt, and the reactor was shut down for their removal. Driver subassemblies previously used were reinserted in place of these experiments for the continuation of Run 25. Measurements related to the power coefficient and associated reactor kinetic studies were then repeated and extended to 45 MWt.

The more precise power-coefficient measurements confirmed the fact that a change had occurred in the power coefficient and that the power reactivity decrement had decreased. It was postulated that the movement of fuel within the limits of available clearances could produce this change. A plan was then formulated to "randomize" the spacing of the core and breeder blanket. It was expected that "randomizing" would increase the reactivity decrement when the reactor was taken from zero to full power. This manipulation involved lowering the holddown fixture on the main fuel-handling gripper, raising the subassembly, and reseating the subassembly in the reactor grid ("jiggling"). The holddown fixture, a portion of the main fuel gripper, physically moves the six surrounding subassemblies just enough to allow the easy removal of the subassembly to be raised. Therefore, "jiggling" one-sixth of the subassemblies should produce effective movement of all subassemblies.

The "jiggling" operations were interrupted, however, when sporadic abnormalities were encountered with certain of the main gripper operations. After subassembly B-341 (grid position 6F4) was lowered, the gripper jaws only opened to an indicated position of 80 percent. Cycling the gripper jaws several times did not increase the jaw travel. After the jaws were closed, the gripper was raised 10 inches, lowered, and again the "jaw open" indication showed about 80 percent travel. After discussions were held with cognizant engineers and approval by management obtained, the gripper was manually rotated a few degrees in an attempt to feel the engagement of the gripper with the top adapter of the subassembly. No rotational resistance was felt except that expected from the packing gland. To determine if the gripper rotational bar was broken, the gripper was manually rotated by cognizant engineers in small increments up to 75 deg. clockwise. Again, there was no significant resistance to rotation. Removal of the subassembly was begun, and the log-count-rate channels showed a significant decrease in counting rate, confirming the removal of the subassembly from the core. Further manipulations were performed after the subassembly had been placed on the transfer arm. Rotational indications revealed some misalignment of the top adapter. The subassembly was then transferred to the Fuel Cycle Facility for inspection, where it was revealed that the top adapter had been twisted as a result of the manual manipulations.

Because of these events, the main gripper was scheduled for immediate replacement, and the primary tank and secondary system were cooled to 500 deg. F. The spare fuel-handling gripper was installed, and the systems were returned to

A. Summary (continued)

700 deg. "standby" condition. The replacement gripper checked out satisfactorily, and randomization of the core continued.

During this same period a conference was held at EBR-II between RDT personnel and cognizant ANL personnel on the subject, "EBR-II Power Coefficient". The purpose of the meeting was to inform RDT personnel of available information on the change in the power coefficient. RDT was concerned about the power-reactivity decrement as exhibited in:

(a) an overall decrease from Runs 1 through 24;

(b) the marked change in power coefficient between Runs 24 and 25;

(c) the decrease in power coefficient during Run 25.

Personnel from Argonne discussed the reactor system and the measurements that had been made pertaining to the power-reactivity decrement. Emphasis was placed on the facts that rod drop tests had indicated no deterioration of prompt negative feedback throughout the operating history of the reactor, and that the change in power decrement did not in any way jeopardize the safety of the reactor. The changes that occurred were believed to be due to mechanical ordering of the subassemblies. An increase in the bowing component between Runs 24 and 25 brought about by the insertion of the stainless steel reflector could be considered as the probable cause of the significant difference in reactivity decrement between the two runs.

Calculations were presented which indicated that the temperature distribution across the two rows of stainless steel reflectors was such that the temperature gradient across the eighth row (second row of stainless steel) shows a reverse temperature gradient. Such a gradient would result in reverse bowing of Row 8 subassemblies producing a so-called "buggy spring" effect and an effective reduction in core diameter.

A model to explain the rather minor, but systematic, changes in reactivity decrement was proposed and called the "blanket drift model". In this model it is proposed that there is a general ordering of the blanket subassemblies outward. This should provide more initial clearances inside the core, and that part of the negative power coefficient which is associated with initial core expansion is not realized. This effect could very well have been emphasized after the insertion of the stainless steel blanket subassemblies in Rows 7 and 8, owing to increased radial forces caused by the "buggy spring" effect of the two rows of stainless steel subassemblies which surround the core.

Other calculations were presented which were preliminary attempts to calculate the mechanical bowing and to estimate the corresponding calculated reactivity effects of these motions. These efforts qualitatively supported the

A. Summary (continued)

general features of a bowing model for the measured reactivity decrement curve.

As a result of these discussions, it was agreed that the "jiggling" experiments would be continued to check the drift model hypothesis. Work would be continued on calculations and investigations of other feasible reactor models, and in view of the need for an understanding of the kinetic behavior of the reactor, the oscillator installation should be expedited.

Following the meeting and the completion of the "jiggling", the reactor was started and the power raised in incremental steps to carefully measure the reactivity decrement and the differential power coefficient up to 45 MW. The experiment did not confirm or refute the drift model hypothesis. The reactor was shut down August 18 to complete Run 25 after 1552 MWd of operation.

Late in August the primary and secondary sodium systems were cooled to 350 deg. F. prior to starting the annual leak-rate tests of the reactor building penetrations for the secondary sodium system piping. The secondary sodium was drained to the storage tank, and the steam generators were placed in dry lay-up. Annual preventive maintenance operations were performed on high-pressure steam valves and other components. The cooling tower basin was drained and cleaned concurrently.

During this maintenance shutdown, work started on the installation of a primary sodium sampling station and a plugging meter valve. This sampling station will obtain a primary sodium sample from the downstream leg of the Fuel Element Rupture Detection (FERD) loop. Following the completion of maintenance work, the secondary sodium and steam systems were heated to 350 deg. F. for sodium filling, and then the plant was brought to "standby" conditions, ready for operation.

Reloading of the reactor for Run 26A involved only the exchange of spent driver subassemblies, with core changes held to a minimum. The installation of new experimental subassemblies and the rotary oscillator rod was deferred so that preliminary physics measurements involving power coefficient, banked rod worth, rod drop experiments, control rod calibrations, and reduced flow experiments could be performed during Run 26A, with a core configuration similar to that of Run 25. The reactor was operated at incremental powers up to 45 MW from September 27 to 29 to accumulate physics data, including verification of the rod bank reactivity effect.

The reactor was shut down September 29. Plant cooldown to 600 deg. F. started immediately for installation of the rotary oscillator rod and drive mechanism, completion of the FERD loop sodium-sampling station, and replacement of the "dynamic" coupling on primary-pump motor-generator set No. 2. The primary pump coupling has been in service since 1963, and had required a periodic overhaul for preventive maintenance.

B. Chronology of Principal Events

Date	Event
7/ 1/67	Plant Status: Run 25 in progress (822 MWd accumulated of 1545 MWd scheduled). Reactor power 30 MW turbine-generator output at 10 MWe. Experimental subassemblies XA08 and XG05 have been reinserted in the reactor,and X011 has been removed to storage basket,because it had been identified as a source of fission gas leakage. 150 MWd of operation were scheduled at these conditions to assure that the source of the fission gas leak had been identified.
7/ 4/67	Shut down reactor after 150 MWd of operation with no abnormal fission gas activity identified.
7/ 5/67	Repaired leak in high pressure flash tank of the blowdown system. Started reactor for completion of Run 25.
7/ 6/67	Reactor at 45 MW. Began test procedure No. 27 (heat rejection capabilities of the condenser cooling water system).
7/ 7/67	Reactor scram caused by loss of site power (lightning). Reactor restarted back to 45 MW.
7/10/67	45 MW operation continued. Concluded test procedure No. 27.
7/14/67	Reactor scram due to incoming line voltage dip. Depressurized steam system for maintenance on valve PS-300 (isolation valve for 1250 psi to 150 psi pressure reducing valve).
7/15/67	Reactor at 45 MW; valve PS 300 back in service.
7/17/67	Began test procedure 28 (reactor building heat rate test). Reactor scram due to voltage dip in incoming lines.
7/18/67	Reactor at 45 MW.
7/20/67	Reactor at 45 MW. Reactor shutdown for insertion of experimental subassemblies X023 and X024 in reactor for one-day irradiation at 30 MW. During reactor startup, the differential power coefficient between 10 and 20 MW was observed to be lower than previously measured values. A program of more precise power coefficient measurements was initiated.
7/21/67	Made power coefficient measurements up to 20 MW and performed rod drop experiments.

B. Chronology of Principal Events (continued)

7/22/67	Performed power coefficient measurements and rod drop experiments up to 30 MW.
7/23/67	Removed experimental subassemblies X023 and X024 from reactor. Power coefficient measurements and rod drops were performed incrementally to 45 MW.
7/24/67	Transferred X023 from the storage basket to FCF. Performed annual leak rate tests on reactor building air supply and exhaust valves. Began "jiggling" operations for randomization of core in an effort to study the effect on the power coefficient.
7/25/67	Replaced variacs in primary auxiliary pump power supply.
7/27/67	Began work on modification of the steam supply to the turbine seals. First encountered trouble with the main fuel handling gripper jaw during"jiggling"operations.
7/31/67	Began primary tank cooldown to 500 deg. F. for removal of core gripper. Removed subassembly B-341 from the primary tank because of suspected damage to top adapter as a result of manual gripper manipulations. Removed argon cooling system relay cabinet in preparation for installation of new one.
8/ 2/67	Reached 500 deg. F. in plant system cooldown.
8/ 5/67	Removed fuel handling gripper from primary tank. Completed modification of steam supply to turbine seals tank for inspection
8/10/67	Installed new fuel handling gripper and began heatup to 700 deg. F.
8/12/67	Reached 700 deg. F. primary tank temperature and checked out the new gripper.
8/14/67	Completed checkout of new relay cabinet for the argon cooling system.
8/15/67	Completed "jiggling" operations for randomization of core.
8/16/67	Started reactor for power coefficient measurement up to 45 MW.

B. Chronology of Principal Events (continued)

8/18/67	Shut down reactor for completion of Run 25. A total of 1552 MWd was accumulated this run.
8/30/67	Began plant cooldown to 350 deg. F. for annual leak rate test of secondary sodium piping penetrations in reactor building.
8/31/67	Reached 360 deg. F. and drained the secondary sodium to the storage tank.
9/ 2/67	Placed steam drum in dry layup condition.
9/ 3/67	Performed preventive maintenance operations on the high-pressure steam valves (packed all valves, lapped steam drum safety valves, etc.).
9/ 5/67	Drained the cooling tower basin for annual cleaning and work on the cooling water valves.
9/ 6/67	Completed annual leak rate test on the secondary piping penetrations.
9/11/67	Began heatup of secondary system to 350 deg. F.
9/12/67	Filled secondary system with sodium at 350 deg. F., and began plant heatup to 700 deg. F.
9/16/67	Sodium system temperature reached 700 deg. F.
9/19/67	Began reloading the reactor for Run 26. Twenty-five subassemblies exchanged.
9/23/67	Started reactor for Run 26 preliminary physics measurements (power coefficient measurements, banked rod worth measurements, rod drop experiments, control rod calibrations, and reduced flow experiments).
9/29/67	Completed physics measurements and shut down the reactor. A total of 96 MWd into Run 26.
9/30/67	Began plant cooldown to 600 deg. F. for installation of oscillator rod in control rod No. 8 position.

C. <u>Production Summary</u> (Fiscal Year 1968)

	First Quarter	
Maximum Possible Production (Days x 45 MW)	4140	
Power Production (MWd)	822	
Plant Factor (%)	19.8	
Power Production (Days)		
Full Power	8	
Reduced Power		
Fission Gas Release Study	4	
Reactor Scrams	2	
Reactor Startup	1	
Reactivity Measurements (Power Coefficient Studies)	12	
Special Irradiation	2	
		29
Non-Power Production (Days)		
Repair Steam Leak	1	
Fuel "Jiggling" (Power Coefficient Study)	7	
Fuel Handling Gripper Replacement	15	
Scheduled Maintenance and Sodium Sampling Modifications	34	
Loading Changes	5	
Oscillator Rod Installation	1	
		63
Total (Days)		92

D. Plant Performance

1. Power Production

The reactor was operated for a total of 822 MWd this quarter. Operating history data is given in Tables I, II, and III. Graphs of critical time, generator on time; reactor ΔT, thermal power, electrical power; and integrated thermal and electrical power are given in Figures 1 through 9. The summary of EBR-II scrams from power is given in Table IV.

a. NRTS Power Disturbances

In July there was a period of considerable instability of the incoming power line to EBR-II. These reoccurring events were felt throughout the Intermountain area and were apparently related to a newly established power tie between the Northwest Power Pool and the eastern part of the United States. This interconnection was established in three places in Montana. The instabilities on the total system were characterized by large oscillations in reactive power being exchanged between the two giant systems. In their milder form, these oscillations were not observed by the electrical consumers. When they became substantial, they ultimately affected line voltage, and during this time have caused considerable chaos, so much that the Northwest Power Pool severed its ties to the eastern system on July 23, 1967.

The EBR-II plant, being a generating facility, saw evidence of the instabilities sooner than other NRTS facilities. The usual pattern of such instabilities was periodic oscillations of approximately eleven seconds. Such oscillations usually damped out before substantial effects were seen in the power or voltage trace. In such cases, the only effect of the instability as seen from EBR-II was in the reactive power trace. No other audible or visual effects were observed. Occasionally these instabilities grew to severe proportions and caused low voltage, resulting in reactor shutdown.

An alarm-only monitor was installed on the reactive power instrument, and a temporary recorder was installed to measure and record EBR-II generator current. An interlock was considered which would trip the tie breaker between EBR-II and NRTS in the event of power oscillations which might cause reactor shutdown.

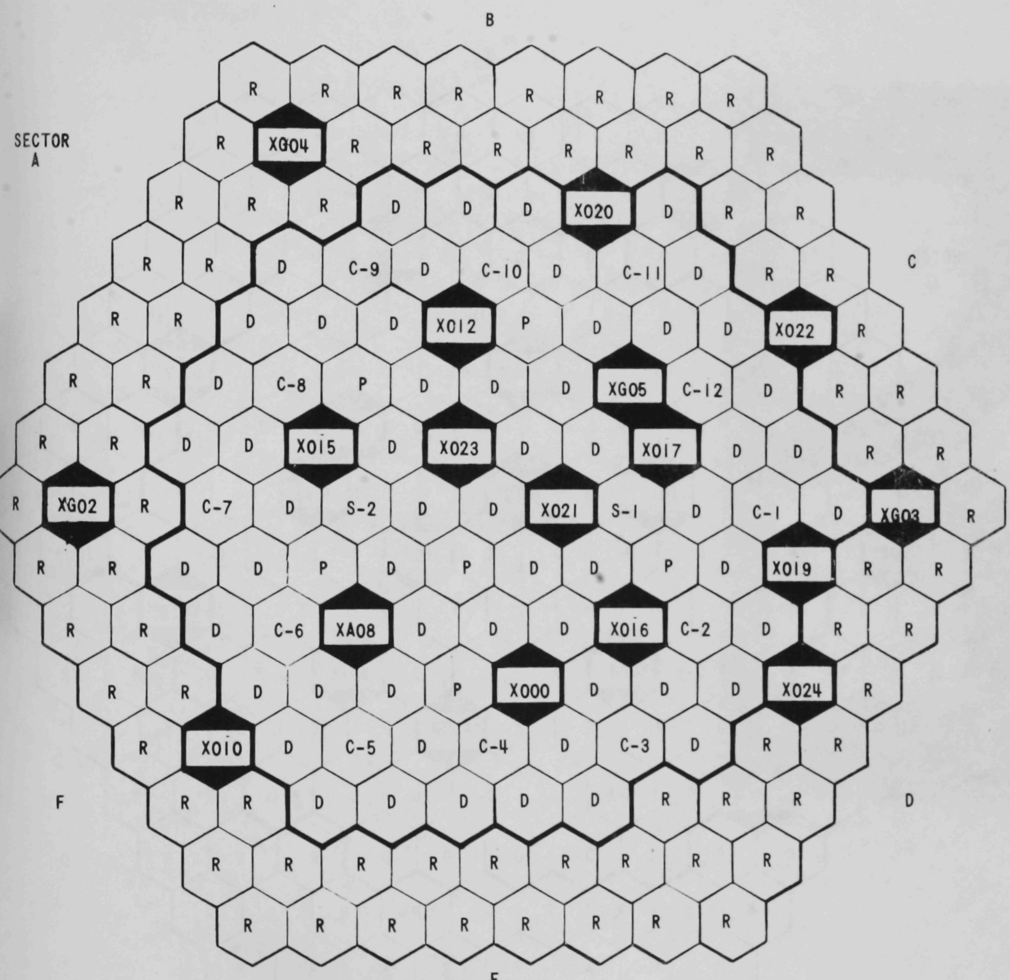
2. Primary System

a. Primary Pumps

The graphs of clutch current, generator power, pump speed and flow, Figures 10 through 15, indicate no appreciable change

NOTE: CONTROL ROD #1 CONTAINS
SST ROD

KEY: D-# DRIVER FUEL 114
C-# CONTROL ROD
S-# SAFETY ROD
P - $\frac{1}{2}$ DRIVER FUEL, $\frac{1}{2}$ SST
R - STAINLESS STEEL REFLECTOR



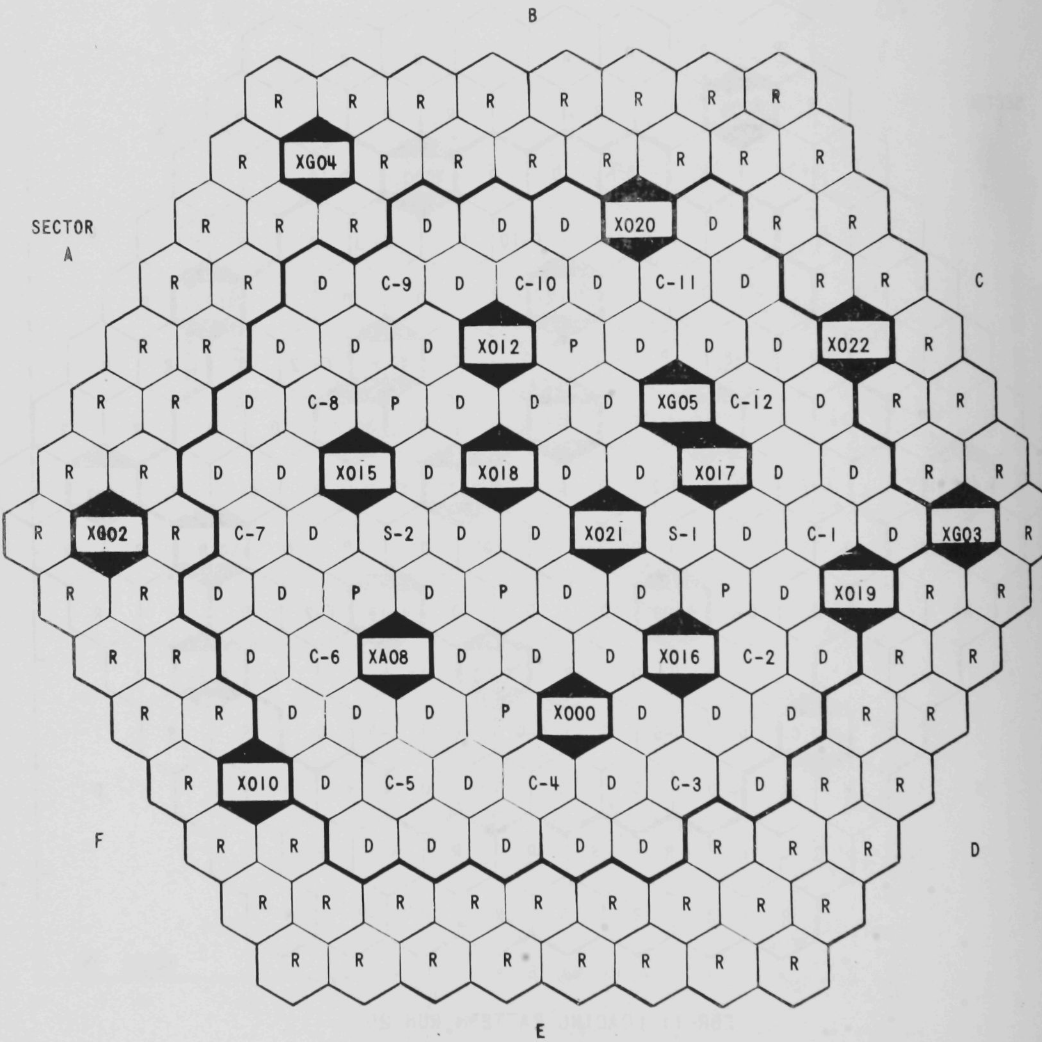
EBR-II LOADING PATTERN RUN 25

7-21-67

FIG. 55

NOTE: CONTROL ROD #1
CONTAINS SST ROD

KEY: D DRIVER FUEL
C# CONTROL ROD
S# SAFETY ROD
P- ½ DRIVER FUEL, ½ STAINLESS ST.
R- SST REFLECTOR



EBR-II LOADING PATTERN - RUN 25 - 7-1-67 7-24-67

EBR-II LOADING PATTERN - RUN 26A - 9-25-67

FIG. 56